

Use of embedded networked sensors for the study of cyanobacterial bloom dynamics

Stauffer, BA,^{1,3} Sukhatme GS,^{2,3} Oberg C,^{2,3} Zhang, B^{2,3}, Dhariwal, A^{2,3}, Requicha, A^{2,3}, Caron, DA^{1,3}
¹Department of Biological Sciences, University of Southern California; ²Department of Computer Science, University of Southern California; ³Center for Embedded Networked Sensors (CENS)

Introduction

Traditional monitoring techniques are limited in the development of predictive models for aquatic microbial populations that requires very fine spatial and temporal resolution of data. The need for continuous (or real-time remote) monitoring of the environment combined with the desire for directed (intelligent or autonomous) sampling has prompted the development of a sensor network. The network incorporates low-energy demand, and highly adaptable sensors which exploit recent advances in computer networking and robotics to process sensor data and ensure high data fidelity. The coordination of stationary sensor nodes and mobile sensing using a sampling robot allow for efficient collection of samples from features of interest, as exemplified in a recent study of a cyanobacterial bloom in Lake Fulmor, California.

Hypothesis

The application of Embedded Networked Sensing (ENS) technology to monitor cyanobacterial bloom in a lake environment will provide new observational capabilities with unique information on the distribution and/or behaviors of planktonic assemblages.

Methods

The sensor network (NAMOS: Networked Aquatic Microbial Observing System) consists of 10 stationary buoys and one mobile robotic boat. Each buoy is equipped with a computer, sensor suite, and wireless communication. They are networked and communicate with each other and a shore-based station via wireless ethernet. Onboard sensors include a thermistor array for measuring water temperature to 3 m depth and a fluorometer capable of detecting chlorophyll (chl *a*) concentrations from 0.5-500 µg/L. The robotic boat is equipped with similar sensors and processing capabilities in addition to a water sampler capable of taking six 4-ml samples. The robotic boat is autonomously controlled using information obtained from the network.

Results

Over the course of a 4-day NAMOS deployment, the chl *a* concentration showed high temporal variability. Cyclic daily variations in subsurface chl *a* fluorescence were observed with a peak between the hours of midnight and 5 am. During this time period, chl *a* concentrations increased from a day-time average of ≈2.5 µg/L to >6 µg/L. *Spirulina* sp. strongly dominated the phytoplankton community. The sensor network also detailed the spatial distribution of photosynthetic organisms along the length of Lake Fulmor, indicating increased concentrations of chl *a* towards the southwest end of the lake.

Conclusion

The presence of daily variations in chl *a* concentration at all static node stations implies a strong vertical migratory behavior of phytoplankton in the lake, most likely *Spirulina*. Accumulations of chl *a* in the southwest corner of the lake suggest reduced mixing or increased nutrients in this deeper, more protected area. And finally, the ability to resolve this trend at several points along Lake Fulmor and over the course of several days, and the combination of these data with autonomously collected water samples, demonstrates a marked improvement over traditional point sampling techniques.